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Doklady Akademii Nauk SSSR, Volume 69, No. 6, pages 789-792

Moscow-Leningrad : 21 December 1949

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EXPERIMENTS WITH A WILSON CLOUD CHAMBER AT AN ALTITUDE OF 3860 METERS ABOVE SEALEVEL

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/Note: The following report appeared in the regular 'Physics' section of the thrice-monthly Doklady Akademii Nauk SSSR, Volume 69, No 6 (21 Dec 1949), pages 789-792./

In order to investigate the strongly ionizing particles which are formed under the action of cosmic radiation, a horizontal Wilson cloud chamber under higher pressure was used in the Pamir expeditions of 1947 and 1948. The chamber's diameter was 16 cm its height 4 cm. The chamber was filled with technical argon under a pressure of 3.5 atm. Mixtures of water vapor and ethyl alcohol served as the condensing gas.

The chamber's sensitivity time could easily be made to reach 1 sec, but fearing distortion by traces we chose it to be 0.5 sec. in the experiments of 1947 and approximately 0.2 - 0.3 sec in 1948.

Photographic pictures were taken by a stereoscopic camera. In 1947 a magnetic field was not yet used. In 1948 the Wilson cloud chamber was placed in a magnetic field of 5000 gauss.

10,000 pictures were obtained in the chamber without magnetic field, of which 7500 were suitable for processing. 7000 pictures of the chamber with magnetic field were also processed. Below we outline the most essential results obtained during the processing of these pictures.

1. Bound Strongly-Ionizing Particles

On 345 pictures obtained in 1947, and on 159 pictures obtained in 1948, respectively 386 and 173 single strongly-ionizing particles were fixed, whose paths in the chambers exceeded the paths of alpha-particles due to radioactive impurities.

Considering the appearance of each of such particles an independent event, we can use Poisson's formula and compute the probability of appearance of n particles during one expansion. The probabilities of n strongly-ionizing particles appearing in one photograph, computed according to the formula:

$$N(n) = \frac{p^n e^{-p}}{n!}$$

(p is the probability of appearance, in a photograph, of a strongly-ionizing particle) and their actual distribution are presented on Table 1.

Number of cases where n particles appear		Number of strongly-ionizing particles in a photograph 0	1	2	3	4
1947 1947	$N_{com}(n)$	7180	354.5	7.5	0.1	
	$N_{exp}(n)$	7189	308.0	34	3.0	
1948	$N_{com}(n)$	6820	156	2	0.013	0.6×10^{-5}
	$N_{exp}(n)$	6817	147	11	0.0	1.0

(Note: 'Com' = computed; 'exp' = experimental.)

As already mentioned, chamber's sensitivity time in the 1948 experiments was a little shorter than that in 1947. For this reason and also because of absorption of such particles by the magnet we find a difference between $N_{exp}(n)$ of 1947 and that of 1948.

Table 1 shows the presence of a considerable excess, over the statistical, of the number of cases of simultaneous appearance of strongly-ionizing particles. This means that nuclear fissions occurring over the Wilson chamber and in its walls, whose /fission's/ products are the particles observed in the chamber, are in genetic connection with each other and are not independent.

Just this fact that these observed particles do not emanate from one point proves that they form as result of several nuclear fissions genetically bound together. Such a conclusion agrees well with the conclusions derived on the basis of the experiments of N. Dobrotin and V. Tsirlin (1) with proportional counters.

2. Particles with Multiple Charge

Some photographs obtained show strongly-ionizing particles forming an anomalously great number of delta-electrons.

Photographs of such particles are shown in Figures 1 and 2. The particle in Figure 1 emerges from the upper glass of the chamber and, after passing through the whole chamber, goes from the illuminated volume to the bottom. The recorded part of the path constitutes not less than 17 cm of air under normal circumstances. Here the primary particle knocks out 6 delta-electrons in its path, whose paths and energies as evaluated from the paths are represented on Table 2.

Using the approximate formula

$$T_{max} = 2mc^2 \frac{\beta^2}{1-\beta^2}$$

(where T_{max} is the maximum kinetic energy transferred by the primary particle to the delta-electron, m is the electron mass, and beta β is the ratio of the particle's velocity to that of light) and taking for T_{max} the value 80 KeV, which is plainly too low, because a delta-electron is not knocked out as a result of a frontal collision, we find the velocity of the primary particle to be $\beta = 0.3$

Table 2

Path, in cm of air, under normal conditions →	8.2	1.5	3.5	2,5	3.5	3.0
Energy in KeV →	80	25	45	35	45	40

For a singly-charged particle, the ionization density corresponding to the indicated value of beta exceeds approximately 4 times the ionization density of a relativistic particle. In actuality the ionization of a primary particle, as is seen from comparison with the ionization of the delta-electrons produced, is at least 20 times higher than that of a relativistic particle.

Because the ionization of a fast particle depends only on its velocity and charges and is independent of mass and because we took for T_{max} a lowered value, than it follows from comparison of ionization density of the primary particle and its generated delta-electrons that the primary particle cannot be singly charged.

The observed ionization density of this particle corresponds to a particle charge of the order 4 - 5e. It may be seen also from the anomalously great number of delta-electrons produced in 1 cm of path (0.35 electron per 1 cm path). Therefore the particle photographed is some light nucleous.

A similar conclusion is drawn from an analysis of the trace of another strongly-ionizing particle, photographed in the chamber with magnetic field (Figure 2). The 2 delta-electrons produced by this particle have energies of the order of 100 KeV each. The specific ionizations of the primary particle and delta-electrons are the same as in the previously considered picture.

From comparison of the considered data it follows that the detected multi-charged particles possess a charge of the order of 4 or 5 elementary charges and are nuclei of light elements. It is known that the presence of multi-charged particles was detected in upper layers of the atmosphere (2).

There is little probability that these particles, subjected to great ionization and nuclear losses, are able to penetrate into the middle layers of the atmosphere. In order to penetrate from an altitude of 28 km to 4 km above sea level, a boron or carbon nucleous should possess a kinetic energy of the order of $5 \cdot 10^{10}$ eV. Particles of such energies were not found by the writers (2).

Therefore we should consider the observed multi-charged particles as products of nuclear fissions occurring in the middle layers of the atmosphere.

In conclusion the writers thank academician D. V. Skobeltsyn for a number of valuable indications in the present work.

Submitted 15 August 1949.

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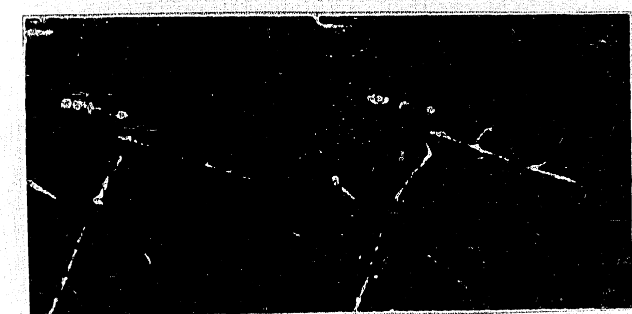

Figure 1

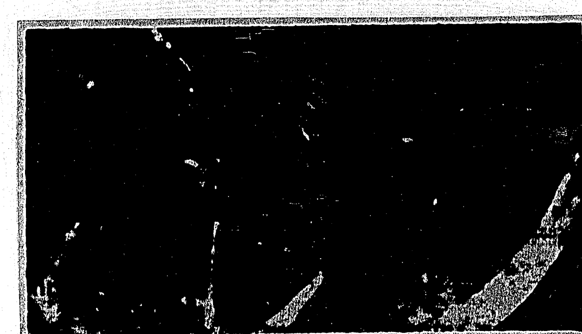

Figure 2.